KWANTLEN UNIVERSITY COLLEGE
CHEMISTRY 1110 R11 Spring 2004
Dr. Jennifer Wolf
EXAM No. 1
Wednesday, February 18, 2004

Name: KEY

Student Number_____

Instructions: Ensure that this exam contains all **eleven** questions. Read the exam carefully and judge your time accordingly. ***All work must be shown to receive any credit.*** If you need extra space, use the back of a preceding page and clearly indicate the question number. Rough work may also be done on the back of a preceding page. A periodic chart is supplied with this exam.
Maximum Score: 70 marks

POTENTIALLY USEFUL INFORMATION:

Avogadro's Number: 6.0221×10^{23}

$PV = nRT$

Gas Constant: $R = 0.08206$ Latm mol^{-1} K^{-1}

1 atm = 760 mm Hg = 760 torr (exactly)

$T(K) = T(°C) + 273.15$

$r_2/r_1 = t_1/t_2 = (MM_1/MM_2)^{1/2}$

$P_{total} = P_1 + P_2 + P_3 \ldots$

$P_i = \chi_i P_{total}$

$c = \lambda\nu$ $\quad E = h\nu$

$h = 6.6.26 \times 10^{-34}$ J s

$c = 2.998 \times 10^8$ m s^{-1}

Question	Marks
1	/5
2	/6
3	/6
4	/6
5	/4
6	/4
7	/6
8	/5
9	/6
10	/14
11	/8
TOTAL	/70

Exam1 ANSWER KEY

Question 1 (5 marks)

A compound containing only Cl and O reacts with hydrogen gas to give 0.233 g HCl and 0.403 g H_2O.

(a) Determine the empirical formula of the compound.

$$0.233\ g\ HCl \left(\frac{1\ mol\ HCl}{36.46\ g}\right)\left(\frac{1\ mol\ Cl}{1\ mol\ HCl}\right) = 0.00639\ mol\ Cl$$

$$0.403\ g\ H_2O \left(\frac{1\ mol\ H_2O}{18.02\ g}\right)\left(\frac{1\ mol\ O}{1\ mol\ H_2O}\right) = 0.02236\ mol\ O$$

$$Cl_{\frac{0.00639}{0.00639}}\ O_{\frac{0.02236}{0.00639}} = ClO_{3.5} \Rightarrow \underline{\underline{Cl_2O_7}}$$

(b) In a separate experiment, HCl gas was found to effuse 2.24 times faster than a gas sample of the chlorine-oxygen compound. What is the molecular formula of the compound?

Gas 2 = HCl Gas 1 = Cl_xO_y

$$\frac{r_2}{r_1} = \sqrt{\frac{MM_1}{MM_2}}$$

$$2.24 = \sqrt{\frac{MM_1}{36.46}}$$

$$5.02 = \frac{MM_1}{36.46}$$

$$MM_1 = 183$$

since $MM(Cl_2O_7) = 182.9$,

molecular formula is $\underline{\underline{Cl_2O_7}}$

Question 2 (6 marks)

A 0.9157 g mixture of $CaBr_2$ and NaBr is dissolved in water and excess $AgNO_3$ is added to the solution to form AgBr precipitate. If the mass of the precipitate is 1.693 g, what is the percent by mass of NaBr in the original mixture?

[Molar masses: NaBr = 102.89 g/mol; $CaBr_2$ = 199.88 g/mol; AgBr = 187.8 g/mol]

$$CaBr_2 + 2\,AgNO_3 \rightarrow Ca(NO_3)_2 + 2\,AgBr\,(s)$$

$$NaBr + AgNO_3 \rightarrow NaNO_3 + AgBr\,(s)$$

Let x = mass in g of NaBr

$0.9157 - x$ = mass in g of $CaBr_2$

$$x\ g\ NaBr\left(\frac{1\ mol\ NaBr}{102.89\ g}\right)\left(\frac{1\ mol\ AgBr}{1\ mol\ NaBr}\right)\left(\frac{187.8\ g\ AgBr}{1\ mol\ AgBr}\right) = 1.825x\ g\ AgBr$$

$$0.9157 - x\ g\ CaBr_2\left(\frac{1\ mol\ CaBr_2}{199.88\ g}\right)\left(\frac{2\ mol\ AgBr}{1\ mol\ CaBr_2}\right)\left(\frac{187.8\ g\ AgBr}{1\ mol\ AgBr}\right) = (0.9157 - x)\,1.879\ g\ AgBr$$

$$1.825x + (0.9157 - x)1.879 = 1.693$$

$$1.825x + 1.721 - 1.879x = 1.693$$

$$0.028 = 0.054x$$

$$x = 0.52\ g = \text{mass of NaBr}$$

$$\therefore \frac{0.52}{0.9157}(100) = 57\%\ NaBr\ \text{by mass in original mixture}$$

Question 3 (6 marks)

A 1.00-g sample of a metal **M** (that is known to form M^{2+} ions) was added to 0.100 L of 0.500 M H_2SO_4 (excess acid). The remaining acid was titrated with 33.4 mL of 0.500 M NaOH. Determine **M**.

Reactions:

M + H_2SO_4 → **M**SO_4 + H_2

H_2SO_4 + 2 NaOH → Na_2SO_4 + 2 H_2O

excess acid:

$$33.4\ mL\ NaOH\left(\frac{1\ L}{1000\ mL}\right)\left(\frac{0.500\ mol}{L}\right)\left(\frac{1\ mol\ H_2SO_4}{2\ mol\ NaOH}\right) = 0.00835\ mol\ H_2SO_4\ excess$$

original acid:

$$0.100\ L\ H_2SO_4\left(\frac{0.500\ mol}{L}\right) = 0.0500\ mol\ H_2SO_4$$

$$0.0500\ mol\ H_2SO_4\ (total) - 0.00835\ mol\ H_2SO_4\ (excess) = 0.00416\ mol\ H_2SO_4\ used$$

$$\Downarrow$$

$$0.00416\ mol\ M$$

molar mass of M: $\frac{1.00}{0.00416} = 24.0$

$\therefore$ M = Mg

Question 4 (6 marks)

Nitric oxide (NO) reacts with molecular oxygen as follows:

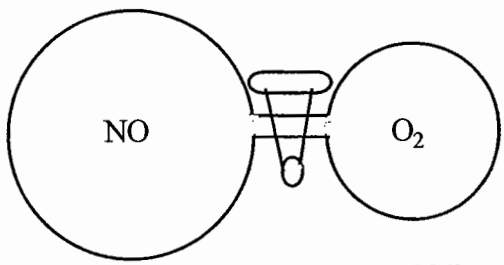
$$2\,NO\,(g) + O_2\,(g) \rightarrow 2\,NO_2\,(g)$$

Initially, NO and O_2 are separated as shown below. When the valve is opened and the gases are allowed to mix, the reaction quickly goes to completion. The temperature remains constant at 25 °C.

Determine:

(a) which gases are present at the end of the reaction
(b) the partial pressures of each gas after the reaction
(c) the total pressure in the system after the reaction

[Note: you can neglect the volume of the connecting tube.]



4.00 L
0.500 atm

2.00 L
752 torr

before reaction:

mol NO: $n = \frac{PV}{RT} = \frac{(0.500\ atm)(4.00L)}{(0.08206\ \frac{L\cdot atm}{mol\cdot K})(298K)} = 0.0818\ mol\ NO$

mol O_2: $n = \frac{PV}{RT} = \frac{(752\ torr)(\frac{1\ atm}{760\ torr})(2.00L)}{(0.08206\ \frac{L\cdot atm}{mol\cdot K})(298K)} = 0.0809\ mol\ O_2$

∴ NO is limiting reagent.

After reaction: $0.0818\ mol\ NO\left(\frac{2\ mol\ NO_2}{2\ mol\ NO}\right) = 0.0818\ mol\ NO_2$

mol O_2 used: $0.0818\ mol\ NO\left(\frac{1\ mol\ O_2}{2\ mol\ NO}\right) = 0.0409\ mol\ O_2$ used

∴ $0.0809 - 0.0409 = 0.0400$ mol O_2 left

Total moles: $0.0818 + 0.0400$
$= 0.1218$ mol total

Total $P = \frac{nRT}{V} = \frac{(0.1218\ mol)(0.08206\ \frac{L\cdot atm}{mol\cdot K})(298K)}{\quad} = 0.496\ atm$

$$P_{O_2} = \frac{0.0400\ mol}{0.1218\ mol}(0.496\ atm) = 0.163\ atm$$

$$P_{NO_2} = \frac{0.0818\ mol}{0.1218\ mol}(0.496\ atm) = 0.333\ atm$$

Question 5 (4 marks)

A ruby laser produces radiation of wavelength 633 nm in pulses whose durations are 1.00×10^{-9} s.

(a) What is the energy of of the radiation produced by the laser (the energy of one "photon")?

$$E = \frac{hc}{\lambda} = \frac{(6.626 \times 10^{-34}\ J \cdot s)(2.998 \times 10^{8}\ m\ s^{-1})}{633\ nm \left(\frac{10^{-9}\ m}{1\ nm}\right)}$$

$$E = 3.13 \times 10^{-19}\ J/photon$$

(b) If the laser produces 0.376 J of energy per pulse, how many photons are produced per pulse?

$$\frac{0.376\ J/pulse}{3.13 \times 10^{-19}\ J/photon} = 1.20 \times 10^{18}\ photons/pulse$$

Question 6 (4 marks)

The energy levels in any one-electron species are given by the expression:

$E_n = -2.179 \times 10^{-18}\ J\ Z^2/n^2$

Calculate the frequency of the radiation emitted when an electron in a Li^{2+} ion falls from n = 4 to the ground state.

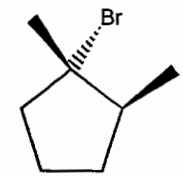
$$\Delta E = (2.179 \times 10^{-18}\ J)(Z^2)\left(\frac{1}{n_i^2} - \frac{1}{n_f^2}\right)$$

$$= 2.179 \times 10^{-18}\ J\left(3^2\right)\left(\frac{1}{4^2} - \frac{1}{1^2}\right)$$

$$= -1.84 \times 10^{-17}\ J$$

$$E = h\nu \Rightarrow \quad \nu = \frac{E}{h} = \frac{1.84 \times 10^{-17}\ J}{6.626 \times 10^{-34}\ J \cdot s} = 2.77 \times 10^{16}\ s^{-1}$$

Question 7 (6 marks)



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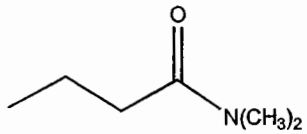

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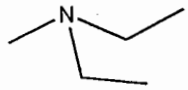

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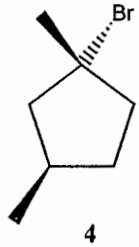

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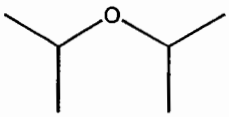

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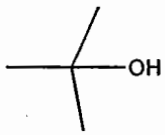

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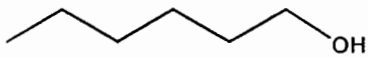

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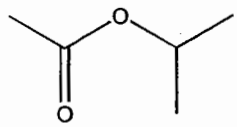
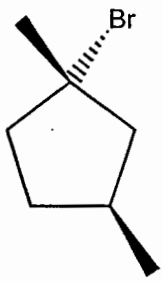
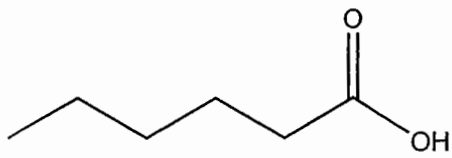


8

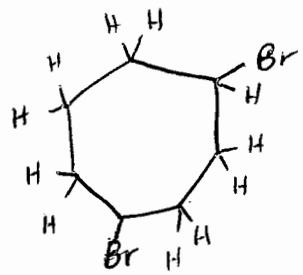
Indicate which of compounds 1-8 above would be examples of the following:
(NOTE: A compound may be used more than once.)

a) amide Answer: 2	b) ether Answer: 5
c) an optical isomer of  Answer: 4	d) a functional isomer of  Answer: 8
e) a compound that will react with $KMnO_4$ Answer: 7	f) a tertiary amine Answer: 3

Question 8 (5 marks)

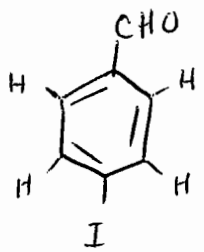
Draw structures (showing **all hydrogens**) of each of the following molecules, and indicate which will show cis/trans isomerism (geometric isomerism):

a) 1,4-dibromocycloheptane



cis/trans

b) para-iodobenzaldehyde



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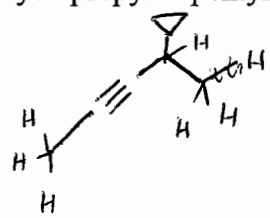
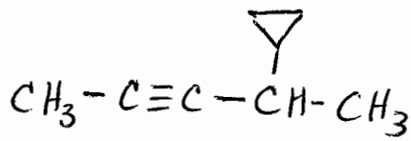
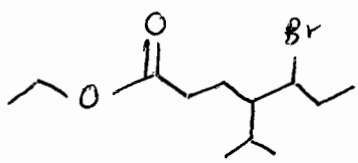
c) 4-cyclopropyl-2-pentyne

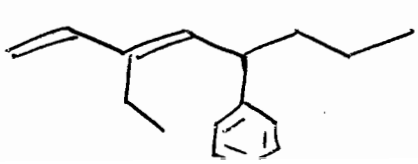




d) ethyl 5-bromo-4-isopropylheptanoate



e) 3-ethyl-5-phenyl-1,3-octadiene

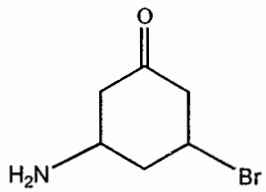


cis/trans possible on second double bond

Question 9 (6 marks)

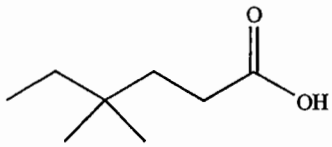
Give systematic names for each of the following:

a)



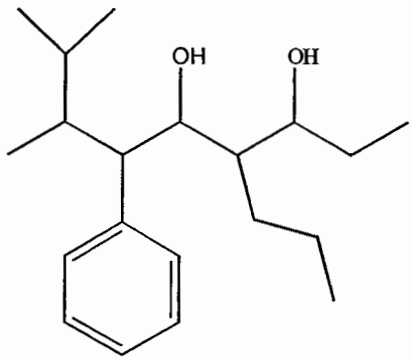
3-amino-5-bromohexanone

b)



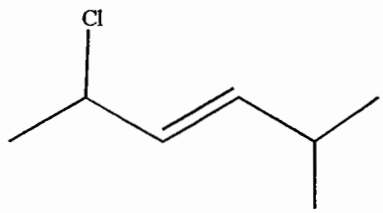
4,4-dimethyl hexanoic acid

c)



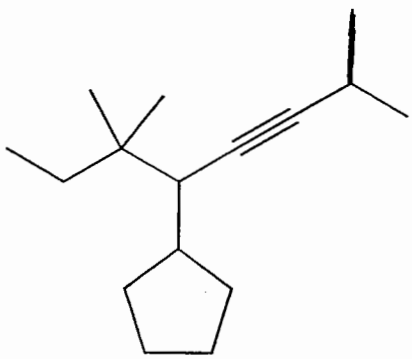
7,8-dimethyl-6-phenyl-3,5-nonanediol

d)



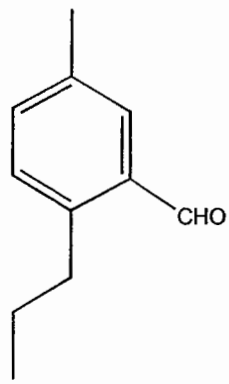
trans-2-chloro-5-methyl-3-hexene

e)



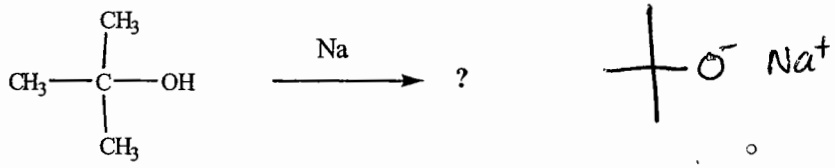
5-cyclopentyl-2,6,6-trimethyl-3-octyne

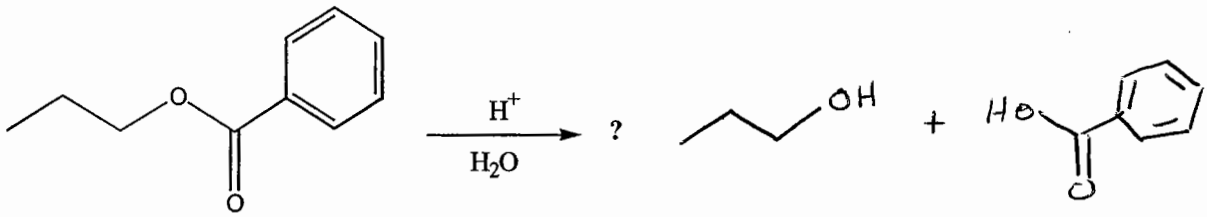
f)

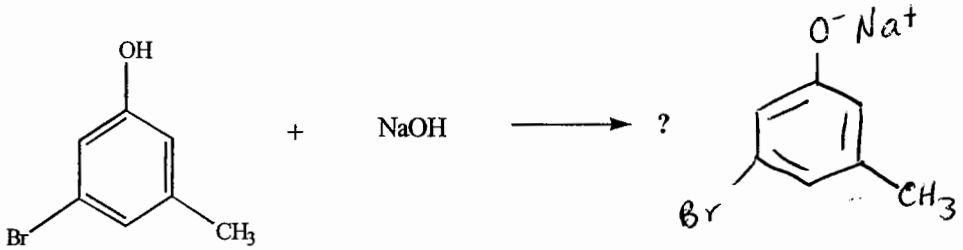


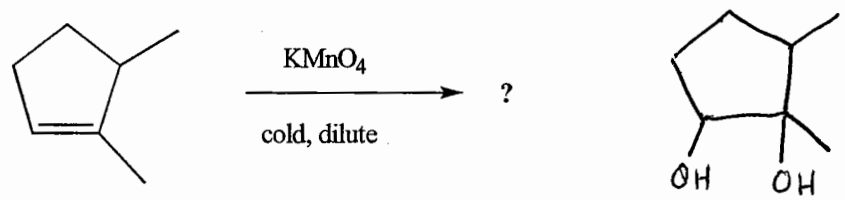
5-methyl-2-propylbenzaldehyde

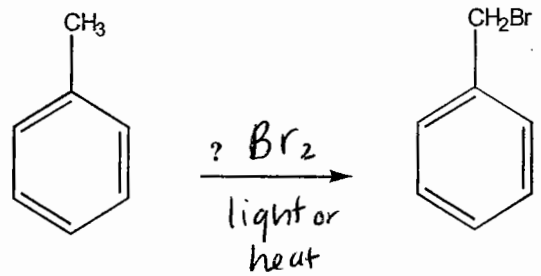
Question 10 (14 marks): Give the major products or fill in the missing reagents for the following reactions:

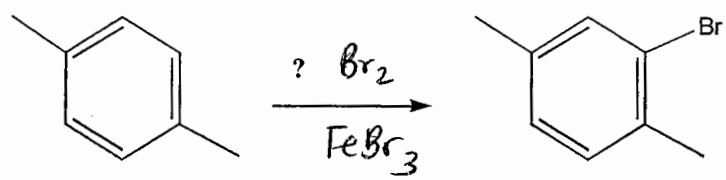
a) 

b) 

c) 

d) 

e) 

f) 

C_nH_{2n-2} one triple bond or two double bonds or two rings or one ring + one double bond

Question 11 (8 marks)

Compound **A** has the formula C_4H_6.

The following scheme show what happens when compound **A** reacts with various substances. Give structures for compounds **A-D**.

A + excess H_2 $\xrightarrow{Pd}$ **B** C_4H_8

A + Br_2 $\longrightarrow$ **C** (has two chiral carbons; mark chiral carbons with *)

A + $KMnO_4$ hot, conc. $\longrightarrow$ **D** $C_4H_6O_3$

A 	**B** 
C 	**D**